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The Ring Nebula in Lyra. By Edward S. Holden, LL.D., Foreign Associate of the R.A.S., Director of the Lick Observatory.

In order to give or to obtain an idea of the power of the 36-inch Clark refractor of the Lick Observatory, it is necessary to compare its performance with that of other telescopes on familiar objects. One of the first objects examined here was the ring nebula of *Lyra*; and I wish to communicate a few particulars regarding its aspect in this telescope, not so much for their strictly scientific value, as to enable others (and myself) to estimate the gain of power by the use of the 36-inch lens.

I had the honour of communicating a note on the same subject to the Society in 1875, which was printed in the *Monthly Notices* for December of that year. I have re-read that note, and the various papers there referred to, and compared them with a pastel drawing of the nebula made by me in 1875 with a power of 400 on the 26-inch refractor at Washington. I find the description of the Washington observations fairly exact, and the pastel drawing to be a good representation of the aspect there. This drawing is deposited in the library of the Lick Observatory. It agrees in general with the drawing made by Mr. Lassell by means of the 4-foot reflector, privately distributed by him in 1860.

I expected that it would be a good representation of the same object as seen here, but in this I was quite mistaken.

The increased brilliancy of the nebula with the larger aperture quite changes its general aspect. It is an entirely hopeless task for me to attempt a drawing of this object as we see it, and therefore I must confine myself to a criticism of my paper of 1875 and to a brief description of the nebula, and wait until we can obtain a photograph of the object which will give the principal details.

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Sir John Herschel's figure (*Phil. Trans.*, 1833, plate x. fig. 29) was made with the 20-foot reflector, but it shows little more than can be seen with the 6-inch finder of the large telescope. D'Arrest's two drawings ("Description of the Copenhagen Equatorial," 1861, plate ii. fig. 5; and Sid. Neb. Obs. Hav.) hardly show more of the nebula. They give beside the 14 magnitude star following the nebula (Lassell No. 1), a 19 magnitude (so-called) star, which is Lassell No. 4. Trouvelot's drawing (plate xxxiv. of "Astronomical Engravings, Harvard College Observatory") shows no stars either within or without the nebula. The criticism on this drawing given in my former paper still seems to me to be true; but, on the whole, Mr. Trouvelot's drawing comes nearer to representing what we see here than any other, not excepting my very careful pastel drawing previously referred to. I presume Mr. Trouvelot's picture to have been made with a high magnifying power.

Lord Rosse's drawing (*Phil. Trans.*, 1844, plate xix. fig. 29) shows seven stars outside the nebula, which I identify as follows:—

Lord Rosse. No.	Lassell. No.	Lord Rosse. No.	Lassell. No.
1	2	5	4
2	1	6	7
3	8	7	11
4	3		

These stars were inserted as in some sense tests of the power of the 3-foot reflector, and we may therefore assume that all stars as faint as Lassell's No. 11 were seen although they are not laid down. (Lassell's fourteen stars are numbered in the order of their brightness.)

At the same time Lord Rosse says that the speculum was probably never in first-class condition when this object was viewed. In Lord Rosse's drawing two very faint stars near No. 8 are also given, which were seen with difficulty. These are not seen here. The drawing of the nebulosity also appears to be faulty in many respects. The nebulosity within the ring is not now arranged in streaks parallel to the major axis as drawn by Lord Rosse, and as partially, and very probably erroneously, confirmed by Professor Abbe, and also by myself in 1875. With this exception, the remarks on this drawing in my paper of 1875 appear to be correct in the light of our recent observations.

Mr. Lassell's drawing of 1860 was made with the 4-foot equatorial. He shows thirteen stars without, and one (No. 14) within the nebula, and says that Nos. 12, 13, and 14 "are near the limit of vision with this telescope." "The star a little below the centre of the dark space in the nebula is faint, and from its faintness, in conjunction with my impression that it does not always appear in precisely the same place, I think there may possibly be

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two nearly equal stars there, too faint to produce distinct sensations on the retina. I see no other stars whatever in the nebula, nor have I the impression that the brightest parts would break up into stars even with far more optical power."

Mr. Lassell's drawing and my own pastel drawing of 1875 represent quite faithfully the appearance of the nebula in the Washington refractor. He gives thirteen stars outside the nebula, as has been said.

In the *Astronomische Nachrichten*, No. 2139, col. 37, Herr Tempel says that with the Amici telescope of 9½ inches aperture he sees twelve faint stars near the ring nebula, but he gives no places for these. Professor Hall in the same journal, No. 2186, col. 27, gives his measures of nine stars near the nebula. I identify these as follows:—

	Hall.	Lassell.		Hall.	Lassell.
	Mag.	No.		Mag.	No.
a	13*	1	*f*	13—14	5
b	14	11	f_1	13 – 14	6
c	13—14	7	f_2	14—15	12
d	12—13	4	*g*	13	8
e	12	3			

Professor Hall says, "I could see no star inside the above ring of stars, nor any star within the ring of the nebula itself. I have been able to see only nine stars near this nebula."

Professor Hall's f_2 is about as faint as any of Lassell's stars outside the nebula, and I am at a loss to understand why he did not include Lassell's No. 13 in his measures, and why he did not see No. 14, which has been well seen by Professor Schultz at Upsula with the Steinheil refractor of 9½ inches, and is seen here with the 12-inch equatorial. Lassell's Nos. 13, 2, 9, 10 clearly belong to the ring of faint stars about the nebula.

The *minimum visible* of a 9½-inch refractor is somewhat fainter than 14 magnitude on Argelander's scale, and it is probable that Herr Tempel's twelve stars were the nine stars measured by Professor Hall, with the addition of Lassell's Nos. 2, 9, and 10.

I now come to the observations made here with the 36-inch telescope by Professor Schæberle and myself jointly. One's first idea is not so much that the aspect is unfamiliar as that it is distinctly different, that its simple structure has suddenly become complex, and finally that the task of depicting it completely is practically impossible by the ordinary methods. On one of the nights of observation Mr. Schæberle and myself were mapping new stars in and about the nebula, and we finally gave up the task not because it was ended, but because it seemed to be endless. The proper method appears to be to photograph the nebula (as we hope to do shortly), and then to add such a description and such measures as may seem to be useful.

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* Professor Auwers calls *a* 11·6 magnitude.

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It will be a matter of intense interest to us to compare our results with those which have been obtained by the great objectives of Pulkowa and Nice, and with those which will be obtained by the great telescopes which are now making for Mr. Common and others. In order to give a test of the light-collecting power of the 36-inch telescope, I may say that Lassell's Nos. 12, 13 (and of course 14) are easily, distinctly, and steadily seen. There are other stars outside of the ring, of which I will mention only two—Nos. 15 and 16. No. 15 is at the vertex of an isosceles triangle, of which the line 5–12 is the base, and whose altitude is twice its base. No. 15 is north of No. 12. No. 16 (first seen by Mr. Keeler) is at the vertex of an isosceles triangle whose base is the line 3–4, and whose altitude is $1\frac{1}{2}$ time its base. No. 16 is north of No. 3; it is about as faint a star as can be seen here (17 magnitude ?).

Our chief attention has, however, been given to stars within the inner dark ring, and to those immersed in nebulosity. Mr. Schæberle (who has first seen most of those within the ring) has used powers of 1344 and less. I have found powers of 672 and less to be best suited for detecting faint stars immersed in the nebulosity or attached to it, as well as for seeing stars within the ring. The stars within the ring and upon the nebulosity are Lassell's No. 14 (which does not always look like a true star, but which is probably not double), and eleven other stars first seen here.

a, *b*, *c*, *d*, *e*, and *h* are within the ring; *g*, *f*, *i*, *j*, *k* are within the nebulosity. The exact position of *h* is somewhat doubtful, and it was only seen by one observer (J. M. S.). The rest have all been repeatedly and steadily seen by both of us. The following diagram gives the approximate positions:—

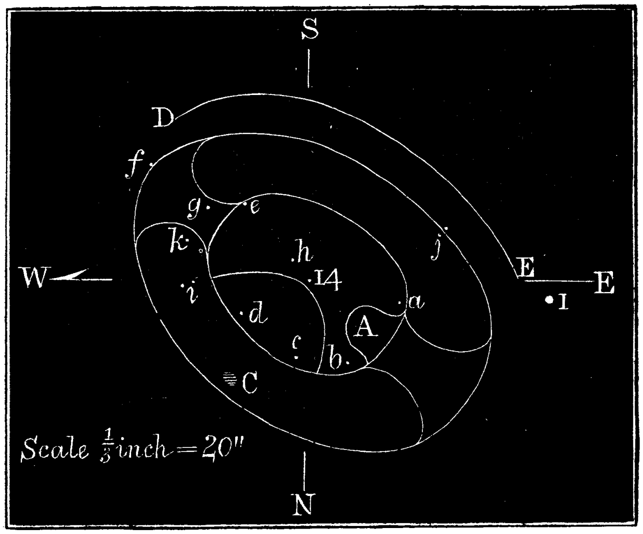

Diagram of the Ring Nebula in *Lyra*, 1888.

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If the star 1 be joined with star 14, then—

Star *a* is just north of this line and inside the ring.
,, *b* is 60° north of this line, and just inside the ring.
,, *c* is 95° north of this line, and just inside the ring.
,, *d* is 150° north of this line (prolonged), and inside the ring.
,, *e* is 135° south of this line (prolonged), and just inside the ring.
,, *f* is just preceding the west end of the major axis.
,, *g* as drawn.
,, *h* (?) as drawn.
,, *i* about in the line 14 to 7.
,, *j* is about 25° south of the line 1 to 14, and just outside.
,, *k* about as drawn.

All of the above are true stars apparently; some of them are remarkably sharp and vivid in their light, notably star *f*.

There are also very many other bright points in the nebula which are presumably stars. Many of these could doubtless be fixed in position if there were any object in so doing. As I have said before, both observers thought such a task to be practically endless.

With regard to the aspect of the nebula, it may be said that the north end of the minor axis is much the best terminated. From the whole south edge faint filaments of nebulosity radiate out about as far as the line DE in the diagram. The preceding end of the major axis is the best terminated. There are several bright patches in the nebulosity, especially at the ends of the minor axis. Patch C in the diagram is about in its true position, and is probably the same patch as that seen and described in 1875. Neither the outer nor the inner boundary curves of the nebula are smooth ovals. Inside the ring it is at once seen that the space on the south and preceding side of the line 1 to 14 is darker than the rest. (See my paper of 1875, where this effect was inadequately described, because imperfectly seen.) The heart-shaped space A on the diagram is relatively bright, and has dark channels north and south of it. The space B is the brightest portion inside the ring.

It is interesting to remark that the ring nebula is situated within what Professor Hall calls a ring of faint stars; that its own shape is bounded by two ovals; that the stars within the ring are either central or on the outer oval of the dark space; and that at least two of the stars projected on the nebulosity are in critical positions on the outer oval.

It only requires a moment's examination of the nebula with this telescope to see that no description or drawing can represent the nebula to another as it is seen; but it seems that even so imperfect an account as the foregoing may suffice to show that the great 36-inch refractor is in fact and at present what Mr.

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Lick's deed required that it should be, "the most powerful in the world." We have but just begun to use it regularly. In many details it is as yet incomplete, but its performance up to this time has proved to us that, if it is rightly used under suitable conditions, it will produce superb results. The chief object of this note is, as I have said, not so much to add any fact of scientific value to what is known, as to enable a judgment to be made of the power of this latest addition to the family of great telescopes.

Lick Observatory, University of California,
Mount Hamilton : 1888, *July* 15.

Observations of Nebulæ at the Lick Observatory. By Edward S. Holden, Foreign Associate of the R.A.S., and J. M. Schæberle.

In the intervals of other work the great equatorial has been turned upon some of the more interesting nebulæ. Our observations of the annular nebula in *Lyra* have already been communicated to the Royal Astronomical Society. We beg to communicate herewith further observations upon nebulæ of the planetary class, one of which (37 H. iv., *Draconis*) has proved to be a highly complex and interesting object of a new class.

Helical-Nebula, 37 *H. iv., Draconis*= *G. C.* 4373.

This nebula (of which a drawing is given) was first viewed here on July 27, 1888.

Its bright blue colour and elliptic shape make it one of the most interesting of the class of planetary nebulæ with central stars. It was examined with powers from 270 to 2000 and even higher, and bears magnifying well, losing only its characteristic and remarkable colour with the higher powers.

The nebula is apparently composed of rings overlying each other, and it is difficult to resist the conviction that these are arranged in space in the form of a true helix. The following diagram will illustrate this.